The Response of Long-Term Interest Rates to News about Monetary Policy Actions

Empirical Evidence for the U.S. and Germany

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Abstract

We reexamine the expectations theory of the term structure focusing on the question how monetary policy actions indicated by changes in the very short rate affect long–term interest rates. Our main point is that the expectations hypothesis implies that very long rates should only react to *unanticipated* changes of the very short rate. In contrast to cointegration tests of expectations theory this implication only requires rational expectations but not stationary risk premia. Therefore, its empirical test sheds new light on the importance of expectations theory for the determinants of the term structure of interest rates.

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1 Introduction

Similar to the U.S. Federal Reserve, the German Bundesbank or the projected European Central Bank, most central banks in developed countries use a short–term interest rate as its main operating instrument. Typically, the instrument is the interbank lending rate for overnight loans, e.g. the 'Federal Funds Rate' for the U.S. and the 'day–to–day rate' for Germany.[1] The flexibility of modern monetary instruments assures that these very short–term interest rates are under the central banks' control. Real activity, however, like investment or consumption, as well as any broadly defined monetary aggregate should depend on long–term interest rates. The transmission mechanism from monetary policy actions to real economic activity and inflation therefore crucially depends on the relation between short– and long–term interest rates, i.e. on the determinants of the term structure.

The most natural explanation for the link between interest rates with different maturities is given by the expectations hypothesis of the term structure where long rates are mainly determined by expectations about future short rates. According to the expectations hypothesis the slope of the term structure contains information about future short–term interest rates and, thereby, about future monetary policy actions. In fact, international evidence suggests that the expectations hypothesis can at least partly explain the development of the short rates on the interbank money market, see e.g. Engsted and Tanggaard (1994) for the U.S., Cuthbertson (1996a) for the U.K. or Hassler and Wolters (1998) for Germany. Apparently, the central banks' tight targeting of

[1]See, for example, Batten et al. (1990) for a detailed comparison of the monetary policy practice in the major industrial countries. A more recent comparison of the Fed's and the Bundesbank's monetary policy practice is provided by Clarida and Gertler (1997). Using the overnight rate as policy instrument, Clarida et al. (1998) estimated remarkably similar policy reaction functions for the Federal Reserve Bank and the Bundesbank.

the interbank overnight rate translates into a relatively tight control of interest rates with a maturity of several months. However, the central banks' influence on interest rates weakens as maturities become longer. In particular, the crucial link between the central banks' operational target variable and very long–term interest rates seems not at all as close as the expectations theory predicts. The cointegration approach for testing the expectations hypothesis, introduced by Campbell and Shiller (1987), usually reveals that there is no stable long–run relation between policy determined short–term rates and typical long–term rates with a maturity of several years, see e.g. Hassler and Nautz (1998). The expectations hypothesis of the term structure seems therefore no firm ground to describe the monetary transmission process.

According to Hardouvelis (1994), two main alternative explanations for the empirical failure of expectations theory have been proposed. The first assumes that market expectations are rational but that the information contained in the term structure is contaminated by nonstationary risk premia. In contrast, the second explanation assumes that risk premia are stationary but that market's expectations are not strictly rational and that long rates therefore tend to overreact to future short rates.[2]

This paper reexamines the expectations theory of the term structure focusing on the question how monetary policy actions indicated by changes in the central banks' operational target affect long–term interest rates. Our main point is that the expectations hypothesis implies that very long–term interest rates should only react to *unanticipated* changes of the very short rate. Since this implication of expectations theory only requires rational expectations but not stationary risk premia, its empirical test sheds new

[2]This point is made forcefully by Froot (1989). Moreover, Culbertson (1957) argued that short and long rates are only loosely connected since arbitrage is limited due to market segmentation. Note that cointegration between interest rates would be distorted by segmented markets even if risk premia were constant.

light on the importance of expectations theory for the link between monetary policy actions and the development of long–term interest rates.

The plan of the paper is as follows. As a starting point of our analysis we follow earlier studies and test the cointegration implications of the expectations hypothesis for U.S. and German data (where the latter can be seen as representative for the coming European monetary union). The results presented in Section 2 show that the long–run implications of the expectations hypothesis hold for short– but not for long–term interest rates. In Section 3 we show that the impact of anticipated changes of a very short rate on a long rate should vanish when the maturity of the latter is sufficiently large. In Section 4, this implication of the expectations hypothesis of the term structure is tested empirically. Section 5 includes a summary and some concluding remarks.

2 Cointegration tests of the expectations hypothesis

2.1 Data description and unit root tests

All data are on a monthly basis and collected from the OECD database (see series 425578AH for the representative U.S. long–term rate (composite over 10 years)) and the Monthly Reports of the Deutsche Bundesbank (see Table VI.7 for U.S. and German overnight and three month rates, respectively, and Table VII.5 for the representative German long–term rate). The sample starts in 1983 in order to avoid the structural break stirred by the Feds so–called monetarist experiment and ends in December 1997. The time series are shown in Figure 1. We denote the overnight rate by r, the three month rate by $r3$ and the typical long–term interest rate by R. German variables are marked with an asterisk.

Figure 1: **Interest Rates in the United States and Germany**

The results of augmented Dickey Fuller Tests presented in Table 1 clearly indicate that all interest rates are integrated of order one ($I(1)$). Estimating relationships between

Table 1: **Unit root tests**

x_t	r_t	$r3_t$	R_t	r_t^*	$r3_t^*$	R_t^*
ADF	-1.53	-1.42	-1.18	-0.68	-0.88	-1.26
x_t	Δr_t	$\Delta r3_t$	ΔR_t	Δr_t^*	$\Delta r3_t^*$	ΔR_t^*
ADF	-6.10	-6.31	-7.02	-6.29	-6.23	-6.30

Notes: ADF denotes the augmented Dickey–Fuller test statistic (with constant). Results are robust with respect to the applied lag specification. The null–hypothesis *"x_t has a unit root"* can be rejected at the 1% resp. 10% level if ADF is smaller than -3.43 resp. -2.58, see MacKinnon (1991).

the levels of interest rates therefore requires cointegration.

2.2 Cointegration tests

Campbell and Shiller (1987) showed that the expectations theory implies bivariate cointegration between interest rates with different maturities *provided* risk premia are stationary. More precisely, the cointegrating parameter should be one implying that the interest rate spreads are stationary. Since this gives two linear independent cointegrating relations for each country, the expectations theory implies that the cointegration rank of the six-dimensional system $(r, r3, R, r^*, r3^*, R^*)$ is at least four. A possible second source of long-run relations is uncovered interest rate parity (UIP) which implies cointegration of domestic and foreign interest rates of the same maturity, see e.g. Kirchgässner and Wolters (1993). Therefore, if UIP holds in conjunction with the expectations hypothesis, then all interest rates should be pairwise cointegrated and the cointegration rank of the whole system should be five.

In order to test for the cointegration rank of the system, we applied the Johansen-test procedure, see Johansen (1995). Table 2 shows that there are only two linear independent cointegrating relations in the system of six interest rates. Whereas the null hypothesis that the cointegration rank does not exceed one ($r \leq 1$) is rejected at the 5% significance level, $r \leq 2$ cannot be rejected even at the 10% level. Normalizing the

Table 2: **Cointegration tests**

Null hypothesis	$r = 0$	$r \leq 1$	$r \leq 2$	$r \leq 3$	$r \leq 4$	$r \leq 5$
Trace statistic	113.69	61.34	34.44	13.90	6.73	1.79
5% crit. value	82.49	59.46	39.89	24.31	12.53	3.84
10% crit. value	78.30	55.54	36.58	21.58	10.35	2.98

Normalized cointegrating vectors

$$r = \underset{(0.07)}{1.034} r3 + \underset{(0.07)}{0.097} R - \underset{(0.07)}{0.024} r3^* - \underset{(0.10)}{0.059} R^*$$

$$r^* = \underset{(0.03)}{0.993} r3^* + \underset{(0.03)}{0.023} R - \underset{(0.03)}{0.042} r3 - \underset{(0.05)}{0.028} R^*$$

Notes: The system under consideration is $(r, r3, R, r^*, r3^*, R^*)$. The null hypothesis "the cointegration rank r is less than k" is rejected if the Trace statistic exceeds the corresponding critical value, see Johansen (1995). Results are based on a VECM without trend and constant. The lag order one is suggested by the AIC and the Schwarz information criterion.

estimated cointegrating relations reveals the economics behind this result: Obviously, the two long-run relations of the system can be identified as $r = r3$ and $r^* = r3^*$. This result can be easily confirmed by unit root tests for the spreads $r3 - r$ and $r3^* - r^*$. The resulting ADF test-statistic (with one lag and a constant) is -3.25 for $r3 - r$ and -3.89

for $r3^* - r^*$ indicating stationarity at the 5% and the 1% significance level, respectively. There is no evidence for an additional cointegrating vector. In particular, long-short spreads (as suggested by the expectations hypothesis) or interest rate differentials (as suggested by UIP) are clearly nonstationary.

In accordance with earlier empirical studies, the cointegration analysis thus supports the expectations theory for the short–term rates of the interbank money market. Market's expectations about the short–term development of the overnight rate are therefore reflected in the slope of the short end of the term structure. For example, if the spread between the three month and the overnight rate is negative, the overnight rate is expected to fall. In fact, in periods of decreasing short–term interest rates the short–end of the term structure is usually inverted, i.e. the spread is negative or at least smaller than on average. As a consequence variations of the central banks' operational instrument are partly anticipated by the market. Note that an analagous conclusion is not feasible for the long end of the term structure. For example, the observation that short–term interest rates exceed the long rate, is generally not very helpful for predicting the future development of interest rates.

The cointegration analysis further indicates that the evidence for UIP is only poor and that the relation between short– and long–term rates is weaker than theory predicts. This failure of the expectations hypothesis is often explained by the presence of non-stationary risk or liquidity premia which distort bivariate cointegration, compare e.g. Evans and Lewis (1994) or Wolters (1998). In the following, we will therefore focus on an implication of the expectations hypothesis that remains valid even if there are non-stationary risk premia. The resulting test of the expectations theory will be especially applicable for the analysis of the crucial link between very short– and very long–term interest rates.

3 How long rates react to changes of the short rate

Let r_t be the one period interest rate and R_t a long–term rate with a maturity of T periods. In our application T is very large, since we focus on the relation between the policy determined overnight rate and bond rates usually having a maturity of several years. Based on a straightforward no–arbitrage condition, the expectations hypothesis of the term structure of interest rates (in its linearized form) states that R_t is the average of future expected short rates plus a risk or liquidity premia φ that may depend on time and maturity:

$$TR_t = r_t + \sum_{i=1}^{T-1} E_t[r_{t+i}] + T\varphi_t \tag{1}$$

where $E_t r_{t+i}$ denotes the expected value of the short–term interest rate in period $t+i$ given the information available in period t. Changes in the long–term interest rate are thus given by

$$T\Delta R_{t+1} \;=\; \Delta r_{t+1} + \sum_{i=1}^{T-1} \Big(E_{t+1}[r_{t+1+i}] - E_t[r_{t+i}] \Big) + T\Delta\varphi_{t+1} \tag{2}$$

or, equivalently,

$$\Delta R_{t+1} \;=\; \frac{1}{T}\sum_{i=0}^{T-1} \Big(E_{t+1}[r_{t+1+i}] - E_t[r_{t+1+i}] \Big) + \frac{1}{T} E_t[r_{t+T} - r_t] + \Delta\varphi_{t+1}. \tag{3}$$

If the expected change of the short rate, $E_t[r_{t+T} - r_t]$, is bounded and T becomes very large, its impact on the long rate vanishes. Equation (3) therefore suggests that long rates change mainly because expectations about future short–term interest rates have been revised. Provided expectations are taken rationally, these revisions only occur if *new* information arrived in $t+1$ implying that long–term interest rates should behave like martingales, see e.g. Cuthbertson (1996b, p249). In particular, long rates should only react to *unanticipated* changes of the short rate. It is worth emphasizing that this implication of expectations theory does not require stationary risk premia. It therefore offers an opportunity to distinguish between the alternative explanations for the empirical failure of expectations theory. Since we will base the following empirical analysis on this intuitive implication of expectations theory we confirm it in the following proposition.

Proposition 1 *Suppose the expectations hypothesis of the term structure (1) holds. Then the response of long rates to* anticipated *changes of short rates gets negligible when the maturity of the long rate is sufficiently large. In the limiting case, the long rate reacts exclusively to* unanticipated *changes of the short rate.*

Proof

Since changes of short–term interest rates are generally found to be stationary (compare the unit root tests in Table 1) we use the Wold–representation and let Δr_t be

$$\Delta r_t = \sum_{i=0}^{\infty} \beta_i u_{t-i} \tag{4}$$

with $\beta_0 = 1$, u_t white noise, and $\sum_{i=0}^{\infty} \beta_i^2 < \infty$. Expectations are revised in response to observed forecast errors. In particular, (4) implies that

$$E_{t+1}[\Delta r_{t+1+i}] - E_t[\Delta r_{t+1+i}] = \beta_i u_{t+1} = \beta_i(\Delta r_{t+1} - E_t[\Delta r_{t+1}]).$$

Using $r_{t+i} = r_t + \sum_{j=1}^{i} \Delta r_{t+j}$ one obtains

$$\begin{aligned} E_{t+1}[r_{t+1+i}] - E_t[r_{t+i}] &= \Delta r_{t+1} + E_t[\Delta r_{t+1+i}] - E_t[\Delta r_{t+1}] \qquad (5) \\ &+ \sum_{j=1}^{i} \Big(E_{t+1}[\Delta r_{t+1+j}] - E_t[\Delta r_{t+1+j}] \Big) \\ &= u_{t+1} \sum_{j=0}^{i} \beta_j + E_t \Delta r_{t+i+1}. \qquad (6) \end{aligned}$$

Hence the expectations hypothesis (see (2)) implies

$$\Delta R_{t+1} = \frac{1}{T}\Delta r_{t+1} + \frac{1}{T}\sum_{i=1}^{T-1}\left(u_{t+1}\sum_{j=0}^{i}\beta_j + E_t[\Delta r_{t+1+i}]\right) + \Delta\varphi_{t+1} \quad (7)$$

$$= u_{t+1}\frac{1}{T}\sum_{i=0}^{T-1}\sum_{j=0}^{i}\beta_j + \frac{1}{T}\sum_{i=0}^{T-1}E_t[\Delta r_{t+1+i}] + \Delta\varphi_{t+1}. \quad (8)$$

Equation (8) shows how long–term rates respond to unanticipated and anticipated changes of short–term interest rates. Let us first look at the role of anticipated changes. The second term can be rewritten as follows:

$$\frac{1}{T}\sum_{i=0}^{T-1}E_t[\Delta r_{t+1+i}] = \frac{1}{T}\sum_{i=0}^{T-1}\sum_{j=0}^{\infty}\beta_{i+1+j}u_{t-j} = \sum_{j=0}^{\infty}\frac{1}{T}\left(\sum_{i=j}^{T+j-1}\beta_{i+1}\right)u_{t-j} \quad (9)$$

Since each coefficient vanishes if T approximates infinity, the total impact of anticipated changes gets negligible if the maturity of R is sufficiently large. On the other hand, one has

$$lim_{T\to\infty}\frac{1}{T}\sum_{i=0}^{T-1}\sum_{j=0}^{i}\beta_j = lim_{T\to\infty}\sum_{i=0}^{T-1}\frac{T-i}{T}\beta_i = \sum_{i=0}^{\infty}\beta_i. \quad (10)$$

Hence the impact of unanticipated changes approximates the long run multiplier given by the Wold–representation of Δr_t. ■

Suppose, for example, that Δr_t follows a stationary AR(1) process, i.e. $\Delta r_t = \alpha\Delta r_{t-1} + u_t$ with $|\alpha| < 1$. In this case one has $\beta_i = \alpha^i$ and the impact of the anticipated change of r_t simplifies to

$$\frac{1}{T}\sum_{i=0}^{T-1}E_t[\Delta r_{t+1+i}] = \frac{1}{T}\frac{1-\alpha^T}{1-\alpha}E_t[\Delta r_{t+1}] \qquad (AR(1)) \quad (11)$$

which vanishes for T large while the impact of the unanticipated change approximates the long run multiplier $\frac{1}{1-\alpha}$. Similarly, if Δr_t follows a MA(1) process, i.e. $\Delta r_t =$

$u_t + \beta_1 u_{t-1}$, the impact of anticipated changes vanishes since

$$\frac{1}{T}\sum_{i=0}^{T-1} E_t[\Delta r_{t+1+i}] \quad = \quad \frac{1}{T}E_t[\Delta r_{t+1}] \qquad\qquad (MA(1)) \tag{12}$$

whereas the unanticipated effect approximates the long run multiplier $1 + \beta_1$.

4 Empirical results

4.1 Forecasting changes of the monetary policy target

In order to test the impact of anticipated and unanticipated changes of the overnight rate on the long rate we forecast the overnight rate using the information contained in the slope of the short end of the term structure. Following the expectations hypothesis, the spread between the rate for three month funds and the overnight rate reveals the market's expectations about future overnight rates. According to the cointegration tests presented in Section 2, any forecast equation for the overnight rate should be specified as error correction equation with the lagged spread to the three month rate as error correction term.

The results obtained for U.S. and German data are shown in Table 3. Note that the estimated forecast errors $\widehat{\varepsilon}_t$ can be interpreted as the unanticipated part of the interest rate change whereas the anticipated part is estimated as $\widehat{\Delta r_t} = \Delta r_t - \widehat{\varepsilon}_t$. In accordance with the expectations hypothesis, observed deviations from the long run equilibrium, i.e. lagged interest rate spreads, explain future changes of the overnight rate. For both countries, the estimated ARCH effects indicate that uncertainty about future monetary policy actions is not constant over time. Taking into account the institutional framework of German monetary policy, we followed Nautz (1998) and

Table 3: **Forecast equations for the overnight rate**

$\Delta r_t = c + \gamma(r3-r)_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta r_{t-i} + \sum_{i=1}^{n} \beta_i \Delta r3_{t-i} + \delta h_t + \varepsilon_t$								
	$\widehat{c}$	$\widehat{\gamma}$	$\widehat{\alpha}_1$	$\widehat{\beta}_1$	$\widehat{\delta}$	R^2	Q(12)	ARCH(4)
U.S.	0.036 (2.14)	0.094 (3.05)	0.294 (3.45)	0.234 (2.47)	–	0.25	7.36 [0.83]	0.38 [0.82]
with $\widehat{h}_t^2 = \underset{(1.75)}{0.004} + \underset{(2.19)}{0.233}\widehat{\varepsilon}_{t-1}^2 + \underset{(7.87)}{0.714}\widehat{h}_{t-1}^2$								
Germany	−0.116 (1.05)	0.319 (5.98)	0.185 (2.81)	–	−1.213 (1.93)	0.27	14.81 [0.25]	0.46 [0.76]
with $\widehat{h}_t^2 = \underset{(5.35)}{0.035} + \underset{(1.87)}{0.257}\widehat{\varepsilon}_{t-1}^2 - \underset{(2.37)}{0.018}V_t$								

Notes: The appropriate lag-orders (m, n) are determined applying a general–to–specific procedure. Robust t-values provided by Bollerslev and Wooldrige (1988) are given in parentheses and p–values in brackets. $Q(12)$ denotes the Ljung–Box statistic against serial correlation up to $12th$ order. $ARCH(4)$ tests against fourth order ARCH–effects.

augmented the German variance equation by a Dummy–variable V that counts how many of the Bundesbank's weekly repo auctions during the last month were conducted as volume tenders, i.e. $V \in \{0, \frac{1}{4}, \frac{2}{4}, \frac{3}{4}, 1\}$.[3] Since the Bundesbank uses volume tenders to reduce interest rate uncertainty, the negatively estimated coefficient of V is correctly signed. Notice further that the German forecast equation is specified as ARCH-M model, see Engle et. al. (1987). In line with Nautz (1998), perceived interest rate uncertainty proxied by the estimated conditional standard error lowers banks' demand for borrowed reserves, and thereby, decreases the day–to–day rate. Remarkably, the

[3] In a volume tender, the repo rate is fixed by the Bundesbank and is common knowledge before the auction starts. In contrast, when the Bundesbank decides to perform its repo auction as an interest rate tender, auction rules are similar to the standard U.S. Treasury Bill auction where the new repo rate is uncertain until the auction result is published. Notice that the unconditional variance of the German interest rate decreases from 0.047 to 0.022 if V turns from 0 to 1.

ARCH-M term played no significant role in the U.S. equation.

4.2 The response of the long–term interest rate

After these preliminaries we can now estimate the impact of unanticipated ($\widehat{\varepsilon}_t$) vs anticipated ($\Delta r_t - \widehat{\varepsilon}_t$) changes of the overnight rate on the typical long–term interest rate. For that purpose, we specified forecast equations for the U.S. and the German long rate and included the anticipated as well as the unanticipated change of the policy instrument as additional regressors:

$$\Delta R_t = c + \sum_{i=1}^{k} \alpha_i \Delta R_{t-i} + \beta_1 \widehat{\varepsilon}_t + \beta_2(\Delta r_t - \widehat{\varepsilon}_t) + u_t. \tag{13}$$

Following the proposition, the expectations hypothesis of the term structure implies that news about the overnight rate influence long–term interest rates while anticipated changes of Δr_t should have no impact. Accordingly, β_1 should be positive and β_2 should be zero. Note that $\beta_1 = \beta_2$ indicates that the long–term rate reacts to the actual change of the policy instrument, whether it has been anticipated or not. In contrast, $\beta_1 \neq \beta_2$ indicates that the proposed decomposition of Δr_t is usefull.

Before we discuss the empirical results, two remarks are in order. First, the forecast equations for the long rates are specified in first differences. In accordance with the cointegration tests presented in Section 2, lagged interest rate levels (domestic or foreign) were not significant for both countries. Yet in order to account for the increasing international integration of the German bond market (see Deutsche Bundesbank (1997)) we augmented the German forecast equation by the change of the U.S. bond rate. It is worth emphasizing that our results do not depend on this extension of the test equation (13).

Second, equation (13) involves *generated* regressors. In this case, the appropriateness of ordinary least squares (OLS) estimation and the validity of standard t-statistics is not obvious. Pagan (1984) has shown that estimation of (13) with OLS is consistent and does not necessarily lead to efficiency losses if (as in our application) generated forecasts $(\Delta r_t - \widehat{\varepsilon}_t)$ as well as forecast errors $(\widehat{\varepsilon}_t)$ enter the equation. The only problem concerns the OLS generated t-statistics of $\hat{\beta}_2$ which tend to be overstated. However this is not a big problem: Since acceptance of the relevant null hypothesis $\beta_2 = 0$ (no influence of anticipated actions) with the overstated $t-$statistic must lead to acceptance with the correct one, see Pagan (1984, p233).

The results for the United States, presented in the upper part of Table 4, confirm the proposition. Equation (14) shows that anticipated monetary policy actions, i.e. forecasted changes of the Federal funds rate, have no impact on the U.S. long–term interest rate ($\beta_2 = 0$) whereas the coefficient of unanticipated monetary policy actions is highly significant and sensibly signed. Moreover, the parameter restriction $\beta_1 = \beta_2$ can be rejected at the 5% level.

Similar results are obtained for Germany, compare equation (15). In particular, the estimated response of the German long rate supports the implication derived from expectations theory: In contrast to forecasted changes of the overnight rate which have no significant influence, the effect of unanticipated changes of Δr_t^* on the long rate is highly significant and correctly signed. In case of Germany, the parameter restriction $\beta_1 = \beta_2$ can be rejected even at the 1% significance level.

Table 4: **The response of long rates to changes of the overnight rate**

Equation for the U.S. long rate:

$$\Delta R_t \quad = \quad \underset{(0.90)}{-0.015} + \underset{(4.94)}{0.426}\Delta R_{t-1} - \underset{(2.95)}{0.225}\Delta R_{t-2} + \underset{(4.59)}{0.359}\widehat{\varepsilon}_t + \underset{(0.10)}{0.015}(\Delta r_t - \widehat{\varepsilon}_t) + \widehat{u}_t \quad (14)$$

$R^2 = 0.28 \qquad Q(12) = 6.82\ [0.87] \qquad ARCH(4) = 0.96\ [0.43]$

Equation for the German long rate:

$$\Delta R_t^* = \underset{(0.83)}{-0.011} + \underset{(4.94)}{0.338}\Delta R_{t-1}^* - \underset{(1.13)}{0.075}\Delta R_{t-2}^* + \underset{(6.36)}{0.307}\Delta R_t + \underset{(4.73)}{0.315}\widehat{\varepsilon}_t - \underset{(0.65)}{0.086}(\Delta r_t^* - \widehat{\varepsilon}_t) + \widehat{u}_t \quad (15)$$

$R^2 = 0.37 \qquad Q(12) = 13.32\ [0.35] \qquad ARCH(4) = 1.97\ [0.11]$

Notes: R denotes the long rate and r the overnight rate. An asterisk denotes the German variables. $t-$values are given in parantheses and $p-$values in brackets. The U.S. equation showed ARCH-effects as follows: $\widehat{h}_t^2 = \underset{(0.73)}{0.001} + \underset{(1.39)}{0.052}\widehat{u}_{t-1}^2 + \underset{(17.85)}{0.926}\widehat{h}_{t-1}^2$. For further explanation see Table 3.

5 Concluding remarks

The most convincing theory for the link between short– and long–term interest rates is given by the expectations hypothesis of the term structure where long rates are mainly determined by expected future short rates. Accordingly, if a central bank is able to control short–term interest rates it should also have a strong impact on the long end of the term structure and, thereby, on real ecomomic activity and inflation. Yet cointegration tests generally indicate that central banks' control over short rates seems not to translate into a strong influence on the levels of long–term interest rates determined in the bond market.

There are two competing explanations for this stylized fact of the term structure of interest rates. On the one hand it is argued that market's expectations are rational but that the link between interest rates is distorted by nonstationary risk premia. On the other hand it is assumed that risk premia are more or less constant but that market's expectations are not formed rationally which typically would lead to an overreaction of the bond market to future short rates. In this paper we derived a testable implication of the expectations hypothesis which might give new insights in the relative importance of nonstationary risk premia and nonrational expectations for the development of long–term interest rates. We showed that if expectations are rational, the expectations hypothesis implies that very long–term interest rates should only react to unanticipated changes of the overnight rate – even if the risk premium is nonstationary. We found strong empirical support in favor of this implication of expectations theory using data for the United States and for Germany whose monetary framework can be seen as representative for the coming European monetary union.

The exclusive response of bond markets to news about the policy determined overnight rate suggests that the missing cointegration of short– and long rates is mainly due to nonstationary risk premia and not to nonrational expectations or to segmented markets. Our results therefore indicate that a deeper analysis of the term structure of interest rates and, thus, of the monetary transmission process requires a better understanding of the determinants of the risk premia involved.

References

Batten, D., Blackwell, M., Kim, I. Nocera, S. and Y. Ozeki. (1990), The Conduct of Monetary Policy in the Major Industrial Countries. *IMF Occasional Papers*, No.70.

Bollerslev, T. and J.M. Wooldridge. (1988), Quasi–Maximum Likelihood Estimation and Inference in Dynamic Models with Time–Varying Covariances. *Econometric Reviews*, 11:143–79.

Campbell, J. Y. and R. J. Shiller. (1987), Cointegration and Tests of Present Value Models. *Journal of Political Economy*, 95:1062–88.

Clarida, R. and M. Gertler (1997), How the Bundesbank Conducts Monetary Policy. In: Romer C., Romer D. (Eds.) *Reducing Inflation*, University of Chicago Press, Chicago.

Clarida, R., J. Gali and M. Gertler (1998), Monetary Policy Rules in Practice. Some International Evidence. *European Economic Review*, 42(6): 1033–67.

Culbertson, J. M. (1957), The Term Structure of Interest Rates. *Quarterly Journal of Economics*, 71:485–517.

Cuthbertson, K. (1996a), The Expectations Hypothesis of the Term Structure: The UK Interbank Market. *The Economic Journal*, 106:578–92.

Cuthbertson, K. (1996b), Quantitative Financial Economics, *Wiley*.

Deutsche Bundesbank. (1997), The Implications of International Influences for Capital Market Rates. *Monthly Reports of the Deutsche Bundesbank* , July, 23–40.

Engle, R., D.M. Lilien and R.P. Robins. (1987), Estimating Time Varying Risk Premia in the Term Structure: The ARCH-M Model. *Econometrica*, 55, 391–407.

Engsted, T. and C. Tanggaard. (1994), Cointegration and the US Term Structure. *Journal of Banking and Finance*, 18, 167-81.

Evans, M.D.D. and K.K. Lewis. (1994), Do Stationary Risk Premia Explain it All? Evidence from the Term Structure. *Journal of Monetary Economics*, 33, 285–318.

Froot, K.A. (1989), New Hope for the Expectations Hypothesis of the Term Structure of Interest Rates. *Journal of Finance*, 44:283–305.

Hardouvelis, G.A. (1994), The Term Structure Spread and Future Changes in Long and Short Rates in the G7 Countries. *Journal of Monetary Economics*, 33:255–83.

Hassler, U. and D. Nautz. (1998), The Link between German Short– and Long–term Interest Rates: Some Evidence against a Term Structure Oriented Monetary Policy. *Jahrbücher für Nationalökonomie und Statistik*, 217(2):214–26.

Hassler, U. and J. Wolters. (1998), The Expectations Hypothesis of the Term Structure: Empirical Evidence for the German Money Market. *Discussion Paper*, Economics Department, FU Berlin.

Kirchgässner, G. and J. Wolters. (1993), Uncovered Interest Parity Conditions between the United States and Europe under Different Exchange Rate Regimes.

In: S.F. Frowen (Ed.): *Monetary Theory and Monetary Policy, St. Martin Press, New York*, 264–97.

Johansen, S. (1995), Likelihood–Based Inference in Cointegrated Vector Autoregressive Models, Oxford Univ. Press.

MacKinnon, J. G. (1991), Critical Values for Cointegation Tests. In: R.F. Engle and C.W.J. Granger (Eds.): *Long–Run Economic Relationships, Oxford University Press*, 267–276.

Nautz, D. (1998), Banks' Demand for Reserves When Future Monetary Policy is Uncertain. *Journal of Monetary Economics*, 42(1):161–83.

Pagan, A. (1984), Econometric Issues in the Analysis of Regressions with Generated Regressors. *International Economic Review*, 25(1):221–47.

Wolters, J. (1998), Untersuchung der Renditestruktur am deutschen Kapitalmarkt 1970–1996. In: Baltensperger. E. (Ed.): *Spekulation, Preisbildung und Volatilität auf Finanz– und Devisenmärkten, Duncker und Humblot, Berlin*, 129–52.